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SYSTEM REQUIREMENTS AND DESIGN FOR THE INTEGRATED EXPOSURE UPTAKE BIOKINETIC MODEL FOR LEAD IN CHILDREN (IEUBK) WINDOWS® VERSION – 32-BIT VERSION

Office of Solid Waste and Emergency Response
U.S. Environmental Protection Agency
Washington, DC 20460

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U.S. ENVIRONMENTAL PROTECTION AGENCY
TECHNICAL REVIEW WORKGROUP FOR LEAD

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System Requirements and Design for the Integrated Exposure Uptake Biokinetic Model for Lead in Children (IEUBK) Windows® version

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1.0 Introduction

1.1 PURPOSE

This System Requirements and Design document is an all-inclusive synopsis of the requirements for the development of the Integrated Exposure Uptake Biokinetic Model for Lead in Children (IEUBK). It documents the design and implementation of the converted program, and is intended as a reference which can be used in the future for model enhancement or modification.

The requirements portion of this document describes, in detail, the parameters and equations that are used in the IEUBK DOS model (v. 0.99d). The design portion describes the structure and details of the design of the model as converted from DOS to a Windows program, version 1.0 for Windows.

1.2 BACKGROUND

The IEUBK model is a stand-alone, personal computer (PC)-compatible software package. The model allows the user to estimate a plausible distribution of blood lead concentrations for a hypothetical child or population of children. This distribution is centered on the geometric mean blood lead concentration which is predicted from available information about the child and his/her exposure to lead. From this distribution, the model estimates the probability that a child's blood lead concentration will exceed a certain level of concern (either user-selected or default). The user also can explore possible changes in exposure media that would alter the probability that blood lead concentrations would be above this level.

The model should be viewed as a tool for making rapid calculations and recalculations of an extremely complex set of equations that include exposure, uptake, and biokinetic parameters. The model was originally developed as a tool for determining site-specific cleanup levels. The Office of Solid Waste and Emergency Response (OSWER) hopes to base the U.S. Environmental Protection Agency (EPA) directives (*e.g.,* the Lead Directive) and future rulemaking on the results produced by the IEUBK model. The IEUBK model has been recommended as a risk assessment tool to support the implementation of the July 14, 1994, OSWER *Interim Directive on Revised Soil Lead Guidance for CERCLA Sites and RCRA Facilities*. The model uses four interrelated components (exposure, uptake, biokinetics, and probability distributions) to estimate blood lead levels in children exposed to contaminated media.

In 1994, Science Applications International Corporation (SAIC) performed an Independent Verification and Validation (IV&V) of the current version of the IEUBK software, version 0.99d, a DOS-based program. Following completion of the IV&V, EPA requested the conversion of the current DOS version to a Windows version. This document addresses the Windows version 1.0 of the IEUBK model (IEUBKwin).

1.3 SCOPE

This System Requirements and Design document encompasses both the intent and purpose of the IEUBK model as well as the programming details, documenting all facets of the program. Rather than incorporate duplicative material, this document references additional sources of information about the model, such as the system documentation for the DOS-based model. This document is not intended as a user's guide or reference manual; both are available as stand-alone documents.

1.4 APPROACH

This document represents a particular step in the information system life cycle. As stated in the *OSWER System Life Cycle Management Guidance* (April 1988):

> "Life cycle management represents a structured approach to solving an information management problem ... starting with the initial identification of the problem, progressing through the building or acquisition of a solution, and ending with the final disposition of the solution at the end of its useful life."

Figure 1 illustrates the five major phases and the stages of the system life cycle which are as follows:

- Initiation
- Concept
- Definition and Design
- Development and Implementation (including testing)
- Operation (stages include production, evaluation, and archive)

The OSWER System Life Cycle is designed to allow flexibility in system development while at the same time providing distinct steps to follow in each phase. Each step has clearly defined:

- Objectives (major accomplishments)
- Key decisions (related to project approach, project execution, and project continuation)
- Products (primarily documentation, but can include other written material and the system itself)

The *OSWER System Life Cycle Management Guidance* includes descriptions of each phase and discussion of the various steps involved in the phase. Outlines are provided for the system documentation requirements which are included in the products within each phase.

In reference to the IEUBK model, the life cycle began with system conception and included system design, development, and implementation. Currently, the IEUBKwin model is in a modification and enhancement stage, in which the system definition, design, development, and implementation phases are repeated.

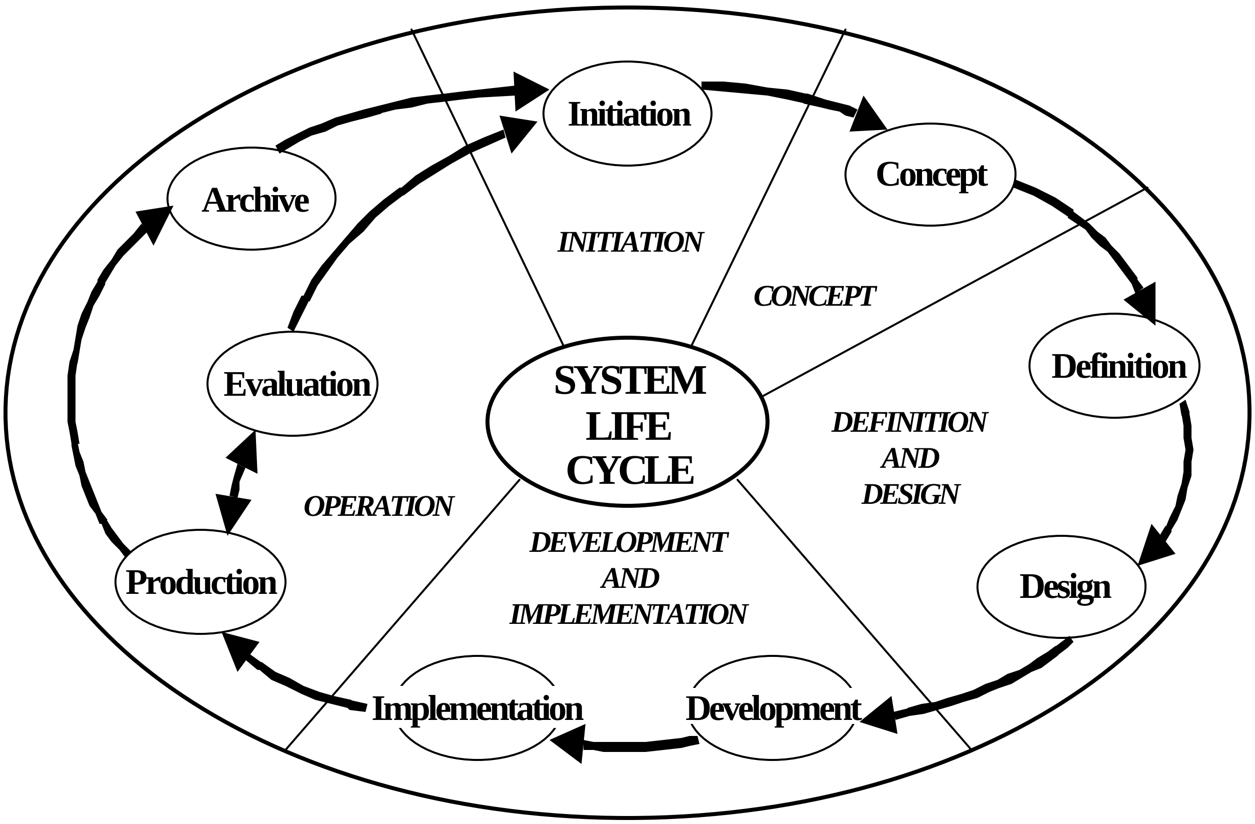

Figure 1. System Life Cycle.

1.5 SYSTEM REFERENCES

The primary reference for the IEUBKwin model is the IEUBK model software (version 0.99d), a DOS-based program. References include the U.S. EPA documents listed in Section 1.7. Additional references are documents prepared in conjunction with the conversion of the model to a Windows-based program.

1.6 TERMS AND ABBREVIATIONS

A number of terms, acronyms, and abbreviations are used throughout this document. Acronyms and abbreviations are identified in parentheses following the first usage of the term. Terms and abbreviations used often in this document are listed in the table below:

Table 1. Terms and Abbreviations

TERM	
Comprehensive Environmental Response, Compensation, and Liability Act	CERCLA
cubic meters	m^3
Disk Operating System	DOS
deciliter	dL
Environmental Protection Agency	EPA
gastrointestinal	GI
gram	g
Independent Verification and Validation	IV&V
Integrated Exposure Uptake Biokinetic Model for Lead in Children	IEUBK
Integrated Exposure Uptake Biokinetic Model for Lead in Children Windows version	IEUBKwin
liters	L
micro	µ
Office of Solid Waste and Emergency Response	OSWER
Resource Conservation and Recovery Act	RCRA
lead	Pb
Technical Review Workgroup for Lead	TRW
Technical Support Document	TSD

1.7 REFERENCED DOCUMENTS

The documents listed below served as references for developing the IEUBKwin model.

- *Correspondence between the IEUBK Lead Model Source Code and Technical Support Document: Parameters and Equations Used in the Integrated Exposure Uptake Biokinetic Model for Lead in Children (version 0.99d),* prepared by Battelle for EPA Office of Pollution Prevention and Toxics, September 30, 1994.

- *EPA System Design and Development Guidance,* June 1989.

- *Guidance Manual for the Integrated Exposure Uptake Biokinetic Model for Lead in Children*, Publication Number, 9285.7-15-1, EPA/540/R-93/081, PB93-963510, February 1994.

- *Phase I Report for the Independent Verification and Validation (IV&V) of the Integrated Exposure Uptake Biokinetic (IEUBK) Model for Lead in Children*, Vols. I and II, prepared by SAIC for EPA Office of Solid Waste and Emergency Response, November 3, 1995.

- *Technical Support Document: Parameters and Equations Used in the Integrated Exposure Uptake Biokinetic (IEUBK) Model for Lead in Children (version 0.99d)*, Publication Number 9285.7-22, EPA 540/R-94/040, PB 94-963505, December 1994.

- OSWER System Life Cycle Management Guidance. OSWER 9028.00, April 1988.

In addition to the documents listed above, the *IEUBK model DOS version 0.99d* source code was used in the conversion to the Windows (version 1.0).

1.8 ORGANIZATION OF THIS DOCUMENT

This document is divided into the following five chapters with four appendices:

1.0 Introduction
2.0 System Requirements
3.0 Software Detailed Design
4.0 Documentation for the IEUBKwin
5.0 Testing and Verification Requirements

Appendix A Equations and Parameters in the IEUBKwin Model
Appendix B Data Crosswalk for the IEUBKwin Model
Appendix C IEUBKwin Parameter Dictionary

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2.0 System Requirements

2.1 SYSTEM DEFINITION

In terms of functionality, the IEUBKwin model is essentially the same as the IEUBK DOS model (version 0.99d). The primary difference is that the IEUBKwin model is implemented as a Windows program. As this task was solely a conversion effort, no attempt was made to modify the program code substantively.

2.1.1 System Concept and Purpose

In order to predict the likely distribution of blood lead concentrations for children between the ages of 6 months and 7 years exposed to lead in environmental media, the IEUBKwin model combines estimates of lead intake from lead in air, water, soil, dust, diet, and other ingested environmental media with an absorption model for the uptake of lead from the lung or gastrointestinal tract, and a biokinetic model of lead distribution and elimination from a child's body.

2.1.2 System Sizing and Timing Requirements

The IEUBKwin model is a stand-alone program that must be capable of performing on a desktop personal computer. For easy distribution and installation, the system should be able to be stored on a single diskette. As a DOS-based model, the IEUBK model functions run quickly on a desktop PC. An important measure of successful development of a Windows-based model is that similar functions, including single runs, multiple runs, and batch runs, perform comparably to the DOS model.

2.1.3 Design Standards

The following design standards from the *EPA System Design and Development Guidance* June 1989 were implemented in recoding the model as a Windows program.

- Utilized structured programming constructs to control the flow of code execution
- Incorporated modularity in source program design and coding
- Adhered to good documentation practices including:
  - Naming conventions
  - Symbolic parameters
  - Paragraphing
  - Blocking
  - Indentation of source code
  - Single statement per line
  - Comments where appropriate
  - Error messages

- Did not use “GO TO” statements

2.1.4 Design Constraints and Assumptions

The EPA required that the IEUBKwin model be portable. Consequently, it was important to efficiently recode the IEUBKwin model. This feature makes distribution of the model both inexpensive and easy. The compiler program, Visual C++ version 6.0, was selected as the development tool for converting the DOS version of the IEUBK model to Windows. This feature makes the IEUBKwin model portable in selected 32-bit Windows environments (Windows 98/ME, Windows 2000, and Windows NT).

With the exception of the errors that were identified in the IV&V and addressed in the recoding, the conversion of the model to Windows assumed that the equations and logic used in the determination of the exposure, uptake, and biokinetic components in the DOS source code were correct.

2.2 SYSTEM HARDWARE AND SOFTWARE REQUIREMENTS

The IEUBKwin model is designed to operate on a specific hardware platform with one of a limited number of operating systems installed. The optimal hardware and software requirements are shown below.

Recommended for Optimum Performance:
- Pentium Processor
  - 200 MHZ (or higher)
  - 32MB RAM
  - 10MB Disk space
  - 32-bit Windows Operating System

2.3 FUNCTIONAL REQUIREMENTS

Figures 2 and 3 are graphical illustrations of the biological and mathematical structures, respectively, of the IEUBKwin model. The biological structure in Figure 2 shows how lead can move from the environment of a hypothetical child into the child’s blood, while the mathematical structure in Figure 3 shows the parameters and calculations necessary to determine the child’s blood lead concentration. Exposure, uptake, and biokinetic components are clearly delineated in the figures and correspond to functions of the IEUBKwin model. Each of these components, plus a fourth component—Probability Distribution—is briefly described below. Beginning in Section 2.3.1, each of the components is described in more detail, from a functional perspective. For each component, these later sections address its purpose, the functions performed in terms of the mathematical equations involved, and the interface between that component and the others.

Descriptions of the database used by each component are not included in these sections because neither the model components nor the IEUBKwin model use separate databases. Refer to the

IEUBKwin model Parameter Dictionary for details about the database. Similarly, a network interface for the components is not addressed; the components are contained within an overall program that is implemented as a stand-alone system.

Exposure Component

As indicated in Figure 2, the exposure component relates environmental lead concentrations to the intake rate at which lead enters the child's body via the gastrointestinal (GI) tract and lungs. The environmental media that serve as lead sources for the child are air, which enters the body through the lungs, and diet, dust, paint, soil, water, and other media which enter the body through the GI tract. As indicated in Figure 3, the exposure component converts media-specific consumption rates (in m^3/day, g/day, or L/day) and media-specific lead concentrations (in μg Pb/m^3, μg Pb/g, μg Pb/L), to media-specific lead intake rates (in μg Pb/day). The media-specific consumption rates and lead concentrations can be modified by the user using site specific data. The general equation relating the consumption rates and lead concentrations to the lead intake rate is:

$$Lead\ Intake\ Rate = Media\ Lead\ Concentration * Media\ Intake\ Rate$$

In this manner, the exposure component determines how much lead enters the child's body and stores that information in a set of media-specific lead intake rates.

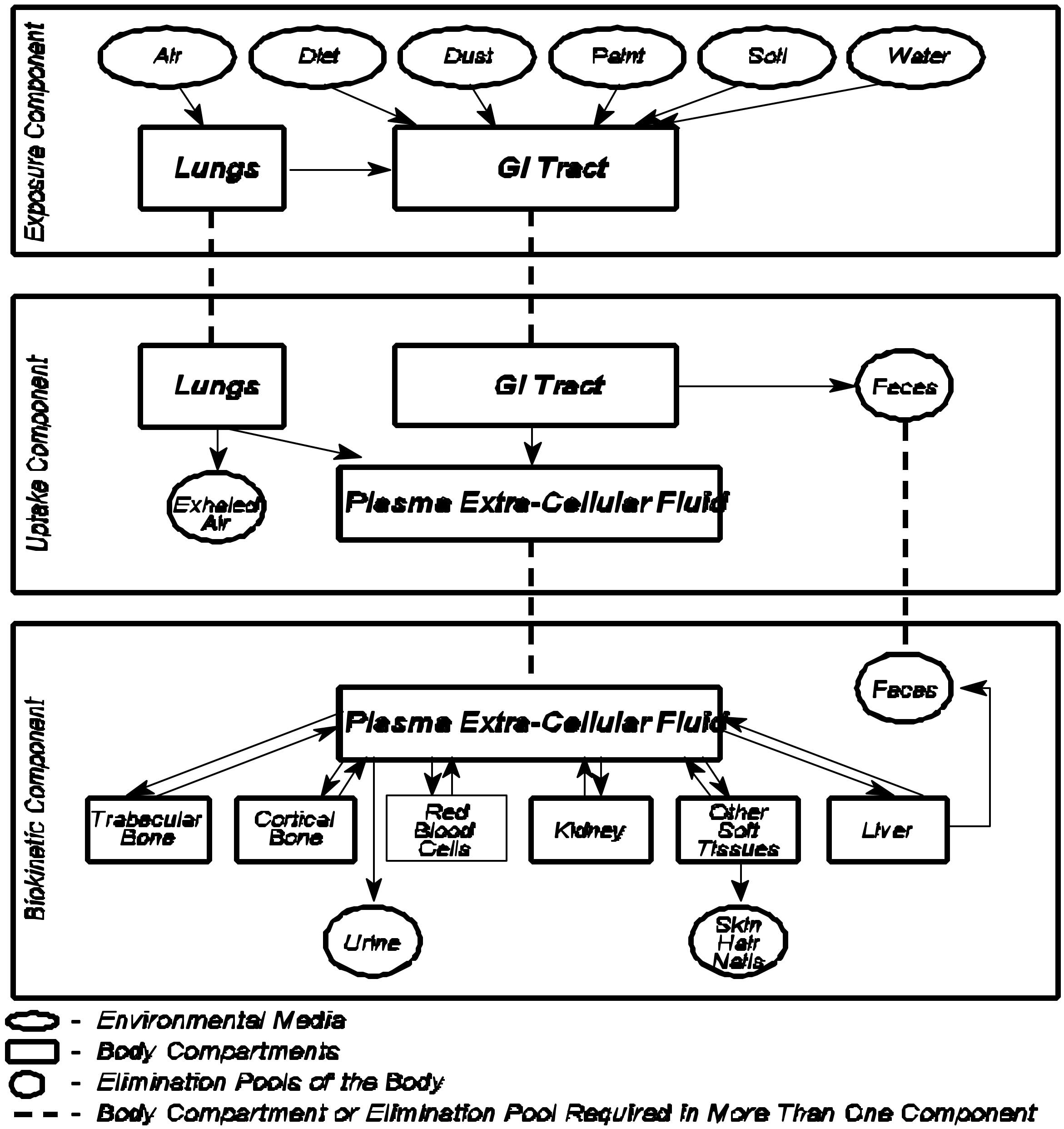

Figure 2. Biological Structure of the IEUBKwin Model.

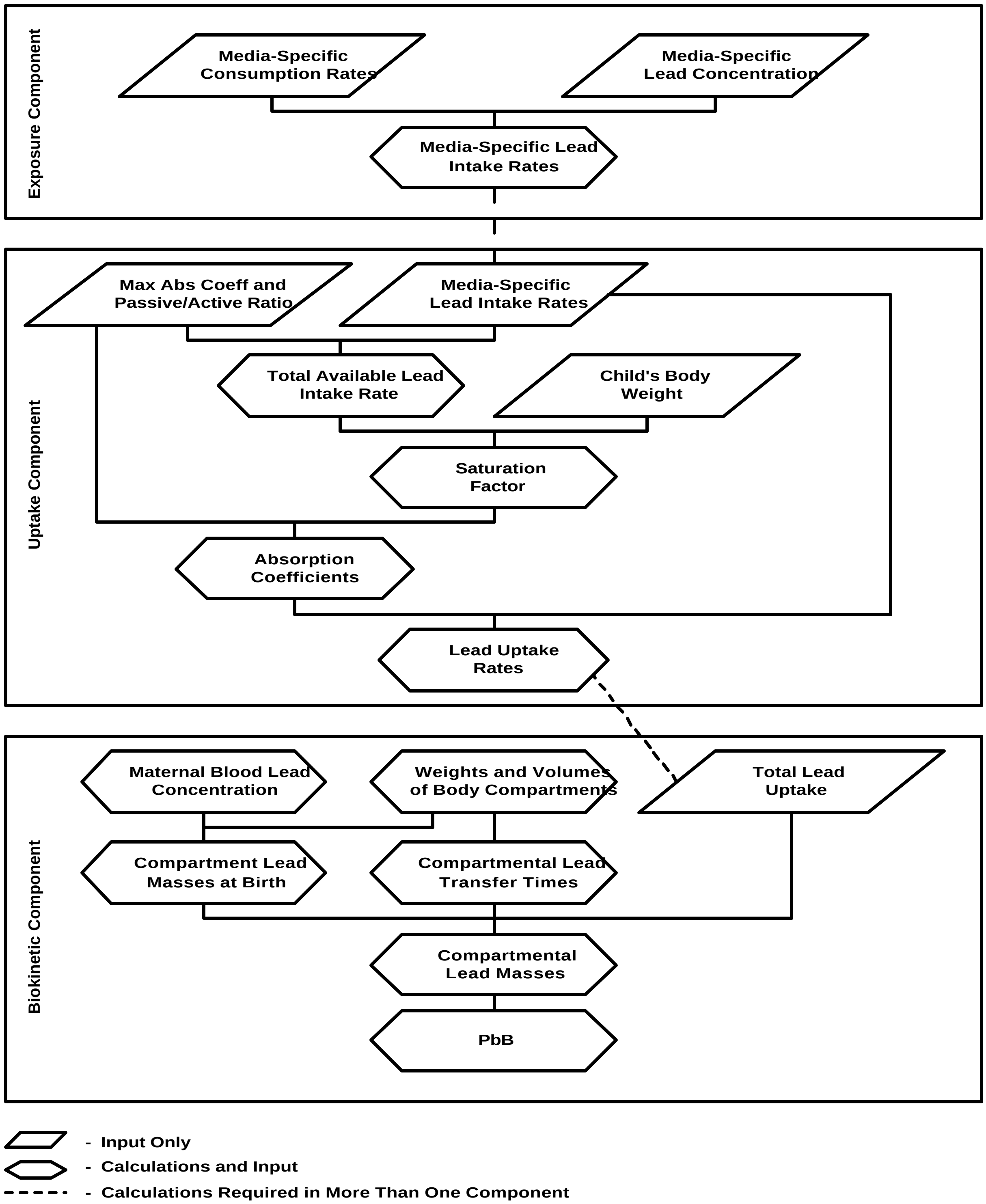

Figure 3. Mathematical Structure of the IEUBKwin Model.

Uptake Component

As indicated in Figure 2, the uptake component relates lead intake into the lungs or GI tract determined in the exposure component to the uptake of lead from the exposed membrane into the child's blood, for children at each age. Lead that enters through the lungs is either absorbed into the blood plasma through the lungs, transferred to the GI tract, or eliminated from the body via exhaled air. Very small particles may move directly into the blood plasma or may be eliminated from the body via exhaled air. Most of the lead found in the human body enters through the GI tract, either through direct ingestion or by movement from the nose, throat or lung structures. Lead that enters the body through the GI tract is either absorbed into the blood plasma or eliminated from the gut with other waste as feces. As indicated in Figure 3, the uptake component converts the media-specific lead intake rates produced by the exposure component into media-specific lead uptake rates (μg/day) for the blood plasma.

The total lead uptake (μg/day) from the GI tract is estimated as the sum of two components, one passive (represented by a first order, linear relationship), the second active (represented by a saturable, nonlinear relationship). These two components are intended to represent two different mechanisms of lead absorption, an approach which is in accord with the limited data available in humans and animals, and also by analogy, with what is known about calcium uptake from the gut. First, the total lead "available" for uptake from the gut is defined as the sum, across all media, of the media-specific intake rate multiplied by the estimated low-dose fractional absorption for that medium. A passive absorption coefficient defines the dose-independent fraction of the available lead that is absorbed by the passive absorption pathway, and allows calculation of the rate of absorption via that pathway. The rate of absorption of the remaining available lead by the active pathway is calculated using a non-linear relationship that allows for saturable absorption.

Biokinetic Component

As indicated in Figure 2, the biokinetic component models the transfer of absorbed lead between blood and other tissues, or elimination of lead from the body via urine, feces, skin, hair, and nails. The biokinetic component of the IEUBK model is structured as a compartmental model of the human body with transfer times between compartments as basic model building elements. The compartmental structure of the IEUBK model was developed by identifying the anatomical components of the body critical to lead uptake, storage, and elimination, and the routes or pathways between these compartments. This compartmental scheme includes a central body compartment, six peripheral body compartments, and three elimination pools. The blood plasma is combined with the body's accessible extracellular fluid (ECF) to form the central plasma/ECF body compartment. Separate body compartments are used to model the trabecular bone, cortical bone, red blood cells, kidney, and liver. The remainder of the body tissues are included in the "other soft tissues" peripheral body compartment. Three elimination pathways are included in the biokinetic model: pathways from the central plasma/ECF compartment to the urinary pool, from the compartment for other soft tissues to skin, hair, and nails, and from the liver to the feces.

As indicated in Figure 3, the biokinetic component converts the total lead uptake rate produced by the uptake component into an input to the blood plasma/ECF. Transfer coefficients are used to model movement of lead between internal compartments and to the excretion pathway. These quantities are then combined with the total lead uptake rate to determine lead masses in each of the body compartments. The lead in the plasma portion of the central/ECF compartment is added to the lead in the red blood cells to determine the blood lead concentration.

The iterative nature of the calculations in the biokinetic component is illustrated in Figure 4. The period of exposure, 0 to 84 months, is divided into a number of equal time steps (within the range of 15 minutes to one month) that are set by the user. During each iteration, compartmental lead masses at the beginning of a time step are combined with the total lead uptake, inter-compartmental transfers, and quantities of excretion during the time step to estimate compartmental lead masses at the end of the time step. The compartmental lead transfer times during the time step are key parameters in these calculations. The compartmental lead masses at the end of the time step then become the compartmental lead masses at the beginning of the next time step and the iterative process continues. The iterative process is initiated by determining the compartmental lead masses at birth from the maternal blood lead concentration and data on the relative concentrations of lead in different tissues of stillborn fetuses. The model calculates all of the compartmental contents from 0 to 84 months; and reports blood lead concentrations from 6 to 84 months.

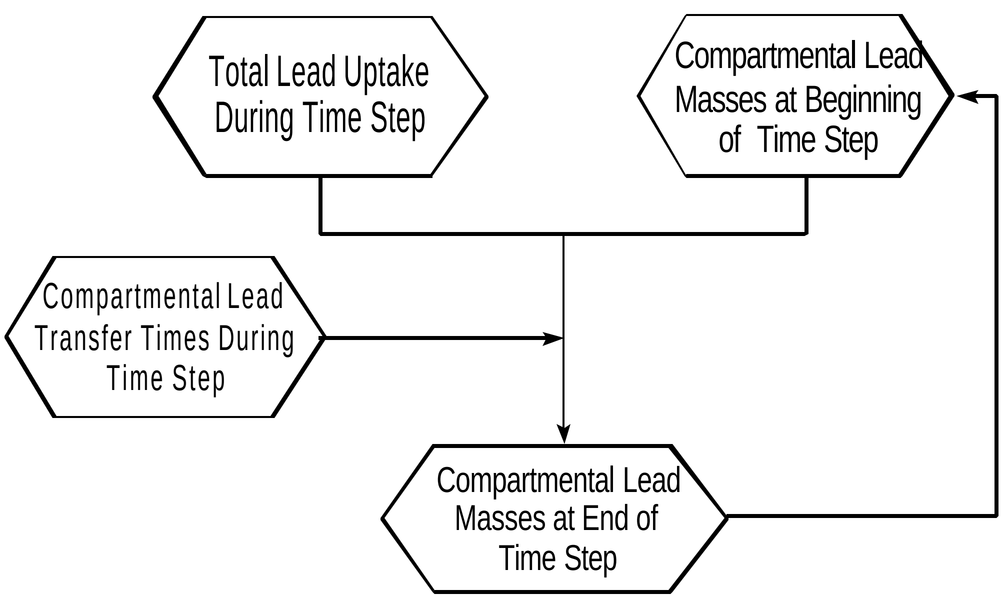

Figure 4. Iterative Procedure for Determining Compartmental Lead Masses in Biokinetic Component.

Probability Distribution Component

The probability distribution component of the model estimates a plausible distribution of blood lead concentrations. The distribution is centered on the geometric mean blood lead concentration for a hypothetical child or population of children. The distribution can be displayed graphically, or the data can be downloaded into another software program for statistical analysis. Descriptive statistics and Plot/Graph are functions of PBSTAT, which uses files with the "*.asc" extension, which are generated from the DOS IEUBK model. To use these functions in the Windows batch mode data, files which have the extension "*.txt", must be renamed with the file extension to "*.asc" using File Manager or Windows Explorer. The *Batch Mode* text results file (*.txt) generated from the IEUBKwin model can be used in the DOS version of PBSTAT by renaming the file extension from *.txt to *.asc in File Manager or Windows Explorer. Note that the *.asc file generated by IEUBKwin will have to be modified for PBSTAT: all the headers must be removed except for the ID FAM BLK line; The P (PbB>C) data column must also be removed; the data should begin on line 4.

2.3.1 Exposure Component

The exposure component of the IEUBKwin model converts media-specific consumption rates and media-specific lead concentrations to media-specific lead intake rates. The media that are included in the exposure component are air, diet, water, soil, dust and paint. The equations that govern these model calculations are listed and discussed below.

In these equations, the lead intake rates for air, diet, household dust, alternate source dust, soil, water, and other ingested media are denoted by INAIR[AGE], INDIET[AGE], INDUST[AGE], INDUSTA[AGE], INSOIL[AGE], INWATER[AGE], and INOTHER[AGE], respectively. The notation "[AGE]" indicates that these intake rates change with the age, t, of the child. All lead intake rates are in units of g Pb/day. Once calculated, media-specific lead intake rates serve as inputs to the uptake component. In the sections below, the calculations required to determine the lead intake rates are discussed by media.

2.3.1.1 Air Lead Exposure Module

The air lead exposure module considers both indoor and outdoor air lead exposure for determining the child's overall air lead exposure. The outdoor air lead concentration [air_concentration[AGE]] is specified by the user. The indoor air lead concentration [IndoorConc[AGE]] is determined according to Equation E-1 as a user-specified, constant percentage [Indoorpercent] of the outdoor air lead concentration. A time-weighted average air lead concentration [TWA[AGE]] is determined according to Equation E-2 where the indoor and outdoor air lead concentrations are weighted by the user-specified, age-dependent number of hours per day that a child spends outdoors [time_out[AGE]]. Finally, the lead intake from air, INAIR[AGE], is calculated according to Equation E-3 as the product of the time-weighted air lead concentration and a user-specified, age-dependent ventilation rate [vent_rate[AGE]].

$$IndoorConc[AGE] = 0.01 * indoorpercent * air\_concentration[AGE] \qquad (E-1)$$

$$TWA[AGE] = \left(time\_out[AGE] * air\_concentration[AGE]\right) + \left[\ \left(24 - time\_out[AGE]\right) * IndoorConc[AGE]\ \right] / 24 \qquad (E-2)$$

$$INAIR[AGE] = TWA[AGE] * vent\_rate[AGE] \qquad (E-3)$$

2.3.1.2 Dietary Lead Exposure Module

Dietary lead exposure, or the lead intake rate from diet [INDIET[AGE]], is determined by one of two methods: (1) direct specification, or (2) the alternative diet model. Under direct specification, INDIET[AGE] is set equal to a user-specified, age-dependent lead intake rate for diet [diet_intake[AGE]], as indicated in Equation E-4a:

$$INDIET[AGE] = diet\_intake[AGE] \qquad (E-4a)$$

Under the alternative diet model, INDIET[AGE] is calculated as the sum of the lead intake rates for meat, vegetables, fruit, and other sources. The first three categories are sub-divided as follows:

- Meat
  – non-game animal (InMeat[AGE])
  – game animal (InGame[AGE])
  – fish (InHomeFish[AGE])

- Vegetables
  – canned (InCanVeg[AGE])
  – fresh (InFrVeg[AGE])
  – home-grown (InHomeVeg[AGE])

- Fruit
  – canned (InCanFruit[AGE])
  – fresh (InFrFruit[AGE])
  – home-grown (InHomeFruit[AGE])

$$INDIET[AGE] = DietTotal[AGE] = InMeat[AGE] + InGame[AGE] + InHomeFish[AGE] + InCanVeg[AGE] + InFrVeg[AGE] + InHomeVeg[AGE] + InCanFruit[AGE] + InFrFruit[AGE] + InHomeFruit[AGE] + InOtherDiet[AGE]^{1} \quad (E\text{-}4b)$$

$$InOtherDiet[AGE] = InDairy[AGE] + InJuice[AGE] + InNuts[AGE] + InBread[AGE] + InPasta[AGE] + InBeverage[AGE] + InCandy[AGE] + InSauce[AGE] + InFormula[AGE] + InInfant[AGE] \quad (E\text{-}4c)$$

With the exception of InOtherDiet[AGE][1], which only uses default values, the terms on the right-hand side of Equation E-4b are defined in Equations E-5a through E-5i. In Equations E-5a through E-5i the model allows the user to vary local dietary factors (*e.g.*, home grown vegetables, fruits, game animals and fish) that may influence overall lead exposure. The user specifies the fraction of total food category consumption represented by each food source. However, the total quantity of food consumption from each category (meat, vegetables, fruit) is a model constant. In Equations E-5a through E-5e, the traditional supermarket portion of the dietary lead intake rate is calculated as the sum of the products of each consumption fraction and the specific lead intake for that category of food. The consumption fraction is calculated as a complement of the user defined nonsupermarket fraction [*i.e.*, 1 - user defined nonsupermarket fraction]:

$$InMeat[AGE] = (1 - userFishFraction - userGameFraction) * (meat[AGE]) \quad (E-5a)$$

$$InCanVeg[AGE] = (1 - userVegFraction) * (can\_veg[AGE]) \quad (E-5b)$$

$$InFrVeg[AGE] = (1 - userVegFraction) * (f\_veg[AGE]) \quad (E-5c)$$

$$InCanFruit[AGE] = (1 - userFruitFraction) * (can\_fruit[AGE]) \quad (E-5d)$$

$$InFrFruit[AGE] = (1 - userFruitFraction[AGE]) * (f\_fruit[AGE]) \quad (E-5e)$$

In Equations E-5f through E-5i, the lead intake rate is calculated as the product of the user-defined nonsupermarket consumption fraction, and a consumption rate for that category of food:

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[1]For the sake of simplification, the term InOtherDiet(t) is used in the text to represent components of the diet other than meat, fruit, vegetables, fish, or game. These other dietary components are modeled as InDairy, InJuice, InNuts, InBread, InPasta, InBeverage, InCandy, InSauce, InFormula, and InInfant. The values for these parameters are defined in the program code for the model and cannot be modified by the user.

$$InHomeFruit[AGE] = userFruitFraction * home\_fruit\_consump[AGE] * UserFruitConc \quad (E-5f)$$

$$InHomeVeg[AGE] = userVegFraction * home\_veg\_consump[AGE] * UserVegConc \quad (E-5g)$$

$$InHomeFish[AGE] = userFishFraction * meat\_consump[AGE] * UserFishConc \quad (E-5h)$$

$$InGame[AGE] = userGameFraction * meat\_consump[AGE] * UserGameConc \quad (E-5i)$$

In Equations E-5j through E-5s, the terms of InOtherDiet[AGE] are defined. All these terms have default values in the model. See Appendix B, the Data Crosswalk for the IEUBKwin model, for the default values.

$$InDairy[AGE] = Dairy[AGE] \quad (E-5j)$$

$$InJuice[AGE] = Juices[AGE] \quad (E-5k)$$

$$InNuts[AGE] = Nuts[AGE] \quad (E-5l)$$

$$InBread[AGE] = Bread[AGE] \quad (E-5m)$$

$$InPasta[AGE] = Pasta[AGE] \quad (E-5n)$$

$$InBeverage[AGE] = Beverage[AGE] \quad (E-5o)$$

$$InCandy[AGE] = Candy[AGE] \quad (E-5p)$$

$$InSauce[AGE] = Sauce[AGE] \quad (E-5q)$$

$$InFormula[AGE] = Formula[AGE] \quad (E-5r)$$

$$InInfant[AGE] = Infant[AGE] \quad (E-5s)$$

2.3.1.3 Water Lead Exposure Module

Water lead exposure is determined by one of two methods: (1) direct specification, or (2) an alternative water lead concentration model. For direct specification, as indicated in Equation E-6a, INWATER[AGE] is calculated as the product of a user-specified, age-dependent water consumption rate [water_consumption[AGE]] and a user-specified, constant water lead concentration [constant_water_conc].

$$INWATER[AGE] = water\_consumption[AGE] * \left(constant\_water\_conc \right) \qquad (E-6a)$$

For the alternative water model, as indicated in Equation E-6b, INWATER[AGE] is calculated as the product of the same user-specified, age-dependent water consumption rate [water_consumption[AGE]] and a constant water lead concentration that is calculated as a weighted average of user-specified, constant water lead concentrations from the first draw on a home faucet [FirstDrawConc], a flushed faucet at home [HomeFlushedConc], and a water fountain outside the home [FountainConc]. These concentrations are weighted by user-specified, constant fractions of consumed water that are first-draw water [FirstDrawFraction], home flushed water [HomeFlushedFraction], and fountain water [FountainFraction]. As indicated in Equation E-7, HomeFlushedFraction is calculated by subtracting the other two fractions from 1.

$$INWATER[AGE] = water\_consumption[AGE] * \begin{pmatrix} HomeFlushedConc * HomeFlushedFraction + \\ FirstDrawConc * FirstDrawFraction + \\ FountainConc * FountainFraction \end{pmatrix} \qquad (E-6b)$$

$$HomeFlushedFraction = 1 - \left(FirstDrawFraction - FountainFraction \right) \qquad (E-7)$$

2.3.1.4 Soil Lead Exposure Module

Equation E-8a is used to determine the soil lead exposure for each of the following ‘constant outdoor soil lead concentration’ conditions:

- Multiple source analysis and constant outdoor soil lead concentration
- Variable indoor dust lead concentration and constant outdoor soil lead concentration
- Constant indoor dust lead concentration and constant outdoor soil lead concentration

$$INSOIL[AGE] = constant\_soil\_conc[AGE] * soil\_ingested[AGE] * \left(0.01 * weight\_soil \right) \qquad (E-8a)$$

where:

constant_soil_conc[AGE] = the constant user-specified soil lead concentration
soil_ingested[AGE] = the user-specified age-dependent soil and dust ingestion rate
0.01 * weight_soil = a user-specified constant fraction of soil and dust ingested that is soil.

However, if none of the three conditions specified above are applicable, Equation E-8b is used to determine the soil lead exposure. Equation E-8b is only applicable if one of the following 'variable outdoor soil lead concentration' conditions exists:

- Multiple source analysis and variable outdoor soil lead concentration
- Variable indoor dust lead concentration and variable outdoor soil lead concentration
- Constant indoor dust lead concentration and variable outdoor soil lead concentration

$$INSOIL[AGE] = soil\_content[AGE] * soil\_ingested[AGE] * \left(0.01 * weight\_soil \right) \qquad (E-8b)$$

where:

soil_content[AGE] = the user-specified age-dependent outdoor soil lead concentration
soil_ingested[AGE] = the user-specified age-dependent soil and dust ingestion rate
0.01*weight_soil = a user-specified constant fraction of soil and dust ingested that is soil

Outdoor soil lead concentration can be specified in an age-dependent manner in the soil/dust data input window.

2.3.1.5 Dust Lead Exposure Module

Dust lead exposure is determined by one of two methods: (1) direct specification, or (2) an alternative dust model. For direct specification, as indicated in Equations E-9a, the baseline dust lead intake, INDUST[AGE], is calculated as the product of a user-specified dust concentration [constant_dust_conc], user-specified age-dependent soil and dust ingestion rate [soil_ingested[AGE]], and the fraction of soil and dust ingestion that is in the form of dust [0.01 * (100 - weight_soil)]. When using the direct specification, the alternative source dust lead intake [INDUSTA[AGE]], is set to zero. Equation E-9a is used if one of the following conditions exists:

- Constant indoor dust lead concentration and constant outdoor soil lead concentration
- Constant indoor dust lead concentration and variable outdoor soil lead concentration

$$INDUST[AGE] = constant\_dust\_conc[AGE] * soil\_ingested[AGE] * \left[0.01 * \left(100 - weight\_soil\right)\right] \quad (E-9a)$$

where:

constant_dust_conc[AGE] = the user-specified dust lead concentration
soil_ingested[AGE] = the user-specified, age-dependent soil and dust ingestion rate
[0.01 * (100 - weight_soil)] = the fraction of soil and dust ingestion that is in the form of dust

The alternative dust sources component has two specifications:

- The indoor dust lead concentration is calculated as a sum of contributions from soil and air, either constant or age-dependent (specific calculations are not shown here, please refer to the Appendix A).

- The indoor dust lead intake [INDUSTA[AGE]] is calculated as the sum of contributions from several additional sources as indicated by Equation E-9c. Only a fraction of dust lead exposure is assumed to come from residential dust. When data are available, the remainder of the dust lead is assumed to come from separately estimated dust sources including:

  - Secondary exposure to leaded dust carried home from the workplace [OCCUP[AGE]]
  - Leaded dust at school or pre-school [SCHOOL[AGE]]
  - Leaded dust at other non-school daycare facilities [DAYCARE[AGE]]
  - Leaded dust from secondary homes (*e.g.*, grandparents) [SECHOME[AGE]]
  - Leaded dust from deteriorating interior paint [OTHER[AGE]]

Equations E-9b and E-9c are used in determining the household indoor dust lead concentration [INDUST[AGE]] and alternative indoor dust lead intake [INDUSTA[AGE]] if multiple source analysis and alternate indoor dust lead sources are used.

$$INDUST[AGE] = DustTotal[AGE] * \left(soil\_indoor[AGE] * HouseFraction \right) \quad (E-9b)$$

$$INDUSTA[AGE] = OCCUP[AGE] + SCHOOL[AGE] + DAYCARE[AGE] + SECHOME[AGE] + OTHER[AGE] \quad (E-9c)$$

In Equation E-9b, INDUST[AGE] is the product of the age-dependent dust ingestion rate [DustTotal[AGE]] (see Equation E-10), an age-dependent indoor household dust lead concentration [soil_indoor[AGE]] (see Equation E-11a), and the fraction of dust exposure that is from residential dust [HouseFraction] (see Equation E-9.5).

The following equations are used to determine the household indoor dust lead intake and alternative indoor dust lead intake if one of the following conditions exists:

- Multiple source analysis and constant outdoor soil lead concentration
- Multiple source analysis and variable outdoor soil lead concentration

$$INDUST[AGE] = soil\_indoor[AGE] * soil\_ingested[AGE] * \left[\ 0.01 * \left(\ 100 - weight\_soil\ \right)\ \right] \tag{E-9d}$$

where:

soil_indoor[AGE] is derived from either Equation E-11a or E-11b

soil_ingested[AGE] is derived from either Equation E-11a or E-11b

[0.01 * (100 - weight_soil)] = the fraction of soil and dust ingestion that is in the form of dust

In Equation E-10, Dust_Total[AGE] is the product of an age-dependent soil and dust ingestion rate [soil_ingested[AGE]] and the user-specified constant fraction of soil and dust ingested that is dust [0.01 * (100 - weight_soil)].

$$DustTotal[AGE] = soil\_ingested[AGE] * \left[\ 0.01 * \left(\ 100 - weight\_soil\ \right)\ \right] \tag{E-10}$$

Equation E-11 has many variations depending on the conditions that exist. In Equation E-11a, soil_indoor[AGE] is calculated as a sum of contributions from soil and air.

$$soil\_indoor[AGE] = \left(\ contrib\_percent * soil\_content[AGE]\ \right) + \left(\ multiply\_factor * air\_concentration[AGE]\ \right) \tag{E-11a}$$

The contribution from soil is the product of a user-specified, constant ratio of dust to soil lead concentrations [contrib_percent] and the user-specified, age-dependent outdoor soil lead concentration [soil_content[AGE]]. Similarly, the contribution from air is the product of a user-specified, constant ratio of dust to air lead concentrations [multiply_factor] and the user-specified, age-dependent outdoor air concentration [air_concentration[AGE]]. This equation only applies if both multiple source analysis and variable outdoor soil lead concentration is used in determining INDUST[AGE].

Equation E-11b is applicable if both multiple source analysis and constant outdoor soil lead concentration are used. The parameter constant_soil_conc[AGE] replaces the parameter soil_content[AGE] and uses the default value for outdoor soil lead concentration instead of a user-specified value.

$$soil\_indoor[AGE] = \left(contrib\_percent * constant\_soil\_conc[AGE] \right) + \left(multiply\_factor * air\_concentration[AGE] \right) \qquad (E-11b)$$

Equation E-9e applies if one of the following conditions exists:

- Variable indoor dust lead concentration and constant outdoor soil lead concentration
- Variable indoor dust lead concentration and variable outdoor soil lead concentration

$$INDUST[AGE] = dust\_indoor[AGE] * soil\_ingested[AGE] * \left[0.01 * \left(100 - weight\_soil \right) \right] \qquad (E-9e)$$

where:
dust_indoor[AGE] = the user-specified age-dependent indoor dust concentration
soil_ingested[AGE] = the user-specified age-dependent soil and dust ingestion rate
(0.01 * (100 - weight_soil)) = the fraction of soil and dust ingestion that is in the form of dust

Equation E-11c is applicable when user-specified, variable household indoor dust lead concentrations are used in conjunction with either constant or variable, user-specified outdoor soil lead concentrations to determine INDUST[AGE] (see Equation E-9e).

$$soil\_indoor[AGE] = dust\_indoor[AGE] \qquad (E-11c)$$

where:
dust_indoor[AGE] = user-specified age-dependent indoor dust lead concentration

$$soil\_indoor[AGE] = constant\_dust\_conc[AGE] \qquad (E-11d)$$

where:
constant_dust_conc[AGE] = default or user-specified constant value for indoor dust lead concentration

As indicated in Equation E-9.5, HouseFraction is determined by subtracting from 1, the total of the user-specified, constant fractions of dust ingested that come from the parent's occupation [OccupFraction], school [SchoolFraction], daycare [DaycareFraction], secondary homes [SecHomeFraction], and paint [OtherFraction]. The sum of all source fractions cannot exceed 1.0. As indicated in Equation E-9c, INDUSTA[AGE] is the sum of the lead intake rates from all five alternative sources. The individual lead intake rates for the alternative sources are defined in Equations E-12a through E-12e. In these equations, the lead intake rate is the product of the age-dependent, dust ingestion rate [DustTotal[AGE]], the user-specified, constant fraction of dust ingested that comes from that source (OccupFraction, SchoolFraction, DaycareFraction, SecHomeFraction, or OtherFraction), and the user-specified, constant dust lead concentration for dust from that source (OccupConc, SchoolConc, DaycareConc, SecHomeConc, or OtherConc).

$$\begin{aligned} HouseFraction = 1 - \big(& OccupFraction - SchoolFraction - DaycareFraction - \\ & SecHomeFraction - OtherFraction \big) \end{aligned} \qquad (E-9.5)$$

$$OCCUP[AGE] = DustTotal[AGE] * OccupFraction * OccupConc \qquad (E-12a)$$

$$SCHOOL[AGE] = DustTotal[AGE] * SchoolFraction * SchoolConc \qquad (E-12b)$$

$$DAYCARE[AGE] = DustTotal[AGE] * DaycareFraction * DaycareConc \qquad (E-12c)$$

$$SECHOME[AGE] = DustTotal[AGE] * SecHomeFraction * SecHomeConc \qquad (E-12d)$$

$$OTHER[AGE] = DustTotal[AGE] * OtherFraction * OtherConc \qquad (E-12e)$$

2.3.1.6 Exposure Component Parameters

For diet, water, and dust exposures, the user may choose from two or more methods of calculating exposure. Each of these exposure pathways has both concentration and intake parameter default values built into the IEUBK model that can be used to calculate default exposure levels. The following sections contain information on the default values for concentration and intake for air, diet, water, soil, and dust.

Parameter Values for Air

The default values for indoorpercent, air_concentration[AGE], time_out[AGE], and vent_rate[AGE] result in the default values shown in the following table:

PARAMETER	DEFAULT VALUE	
IndoorConc[AGE]	0.03 µg/m^3	1S7
TWA[AGE]	0.033 µg/m^3 0.036 µg/m^3 0.039 µg/m^3 0.042 µg/m^3 0.042 µg/m^3 0.042 µg/m^3 0.042 µg/m^3	1 2 3 4 5 6 7
INAIR[AGE]	0.07 µg/day 0.11 µg/day 0.19 µg/day 0.21 µg/day 0.21 µg/day 0.29 µg/day 0.29 µg/day	1 2 3 4 5 6 7

Parameter Values for Diet

The default values for the lead intake rate from diet are shown in the following table:

PARAMETER	DEFAULT VALUE (µg/day)	AGE INTERVAL (year)
INDIET[AGE] (Direct specification)	5.53 5.78 6.49 6.24 6.01 6.34 7.00	1 2 3 4 5 6 7
INDIET[AGE][1] (Alternative diet specification)	5.88 5.92 6.79 6.57 6.36 6.75 7.48	1 2 3 4 5 6 7

[1]The model assumes no consumption of game animal meat, fish, home-grown vegetables or home-grown fruit unless specified by the user.

Parameter Values for Water

Using the default values for water_consumption[AGE] and constant_water_conc results in the default values shown in the following table:

PARAMETER	DEFAULT VALUE (µg/day)	
INWATER[AGE] (Direct Specification)	0.80 2.00 2.08 2.12 2.20 2.32 2.36	1 2 3 4 5 6 7
INWATER[AGE] (Alternative Water Model)	0.77 1.92 2.00 2.04 2.12 2.23 2.27	1 2 3 4 5 6 7

Parameter Values for Soil

Using the default values for constant_soil[AGE], soil_ingested[AGE], and weight_soil results in the default values shown in the following table:

PARAMETER	DEFAULT VALUE	
Soil-derived exterior dust ingestion rate	38.25 mg/day 60.75 mg/day 60.75 mg/day 60.75 mg/day 45.00 mg/day 40.50 mg/day 38.25 mg/day	1 2 3 4 5 6 7
INSOIL[AGE]	7.65 μg/day 12.15 μg/day 12.15 μg/day 12.15 μg/day 9.00 μg/day 8.10 μg/day 7.65 μg/day	1 2 3 4 5 6 7

Parameter Values for Dust

Using the default values for soil_ingested[AGE], percent_soil, and dust_indoor[AGE] results in the default values shown in the following table:

PARAMETER	DEFAULT VALUE	
DustTotal[AGE]	46.75 mg/day 74.25 mg/day 74.25 mg/day 74.25 mg/day 55.00 mg/day 49.50 mg/day 46.75 mg/day	1 2 3 4 5 6 7
INDUST[AGE]	9.35 μg/day 14.85 μg/day 14.85 μg/day 14.85 μg/day 11.00 μg/day 9.90 μg/day 9.35 μg/day	1 2 3 4 5 6 7
INDUSTA[AGE]	0 μg/day	1S7

Parameter Values for Alternative Dust

The default values for the alternative dust module are as shown in the following table:

PARAMETER	DEFAULT VALUE	
DustTotal[AGE]	46.75 mg/day 74.25 mg/day 74.25 mg/day 74.25 mg/day 55.00 mg/day 49.50 mg/day 46.75 mg/day	1 2 3 4 5 6 7
soil_indoor[AGE]	150 μg/g	1S7
INDUST[AGE]	8.42 μg/day 13.37 μg/day 13.37 μg/day 13.37 μg/day 9.90 μg/day 8.91 μg/day 8.42 μg/day	1 2 3 4 5 6 7
INDUSTA[AGE]	0 μg/day	1–7

2.3.2 Uptake Component

The uptake component models the manner in which lead intake (lead that has entered the child's body through ingestion or inhalation) is either transferred to the child's blood plasma or eliminated from the body. The equations that govern the uptake of lead into the blood plasma are discussed in this section. As noted in the previous section describing the exposure component of the IEUBKwin model, the notation [AGE] following a parameter name indicates that the parameter changes with the age of the child. The total of the lead uptake rates is the primary input to the biokinetic component of the model.

The fraction of lead intake that is actually absorbed into a child's system is known as the absorption fraction. The IEUBKwin model is structured so that the media-specific absorption fractions are constant at typical blood lead concentrations of concern. The media-specific absorption fractions include:

- ABSF for dietary lead absorption
- ABSD for dust lead absorption
- ABSS for soil lead absorption
- ABSW for drinking water lead absorption
- ABSO for paint chips lead absorption

In the absence of saturation effects, total lead absorption is equal to the sum of media-specific absorption values where absorption from each media is equal to the intake rate multiplied by the absorption fraction for that media. This quantity is denoted AVINTAKE, and is calculated using the Equation U-2:

$$\begin{aligned} UPPOTEN = & \left(ABSD * INDUST[AGE] \right) + \left(ABSD * INDUSTA[AGE] \right) + \left(ABSF * INDIET[AGE] \right) + \\ & \left(ABSP * INOTHER[AGE] \right) + \left(ABSS * INSOIL[AGE] \right) + \left(ABSW * INWATER[AGE] \right) \end{aligned} \tag{U - 2}$$

To more accurately model lead uptake at higher intake rates, absorption fractions must be modified to separate non-saturable and saturable components. At doses where saturation of absorption is important, the actual uptake of lead will be less than UPPOTEN[AGE]. Lead uptake by the passive pathway is assumed to be linearly proportional to intake at all dose levels. The user parameter PAF is the fraction of the total net absorption at low intake rates that is attributable to non-saturable processes. Specifically, the lead uptake by the <u>passive</u> pathway is equal to:

$$PAF * UPPOTEN[AGE]$$

The IEUBKwin model assumes that the fraction of absorbed lead intake that is absorbed by non-saturable processes is the same for all media. At low doses, the quantity of lead absorbed by the <u>saturable</u> pathway is:

$$\left(\ 1 - PAF \ \right) \ * \ UPPOTEN[AGE]$$

However, at higher doses, only a certain fraction of this amount will be absorbed. The key parameter in this relationship is SATUPTAKE[AGE], which represents the level of available intake (UPPOTEN) at which the saturable pathway uptake reaches half of its maximum value. This half-saturation parameter depends on the age [AGE] of the child. The user can modify the value of SATUPTAKE[AGE] at age t = 24 months, denoted SATINTAKE2, through the GI/Bioavailability selection from the *Parameter Input* menu. From SATINTAKE2, the IEUBK model calculates SATUPTAKE[AGE] for all ages using Equation U-3. The parameter WTBODY(24) in the IEUBK model source code has a default value of 12.3.

$$SATUPTAKE[MONTH] \ = \ SATUPTAKE2 * \left(\ WTBODY[MONTH] \ / \ WTBODY[24] \ \right) \ ] \qquad (U - 3)$$

The fraction of potential saturable pathway uptake that is actually absorbed is given by:

$$1 / \left[\ 1 \ + \left(\ UPPOTEN[AGE] \ / \ SATUPTAKE[AGE] \ \right) \ \right]$$

Thus, the amount of lead that is absorbed by saturable processes is calculated as:

$$\left(1 - PAF \ \right) * UPPOTEN[AGE] / \left[\ 1 \ + \ \left(\ UPPOTEN[AGE] \ / \ SATUPTAKE[AGE] \ \right) \ \right]$$

Total lead uptake from a medium is given by the sum of the active and passive components of uptake. Media-specific uptake rates are calculated using the same proportions as total intake. For example, the non-saturable uptake component for soil is given by:

$$INSOIL[AGE] * \ ABSS * AVS * PAF$$

Whereas the saturable uptake component for soil is:

$$\left(1 - PAF \right) * INSOIL[AGE] * ABSS * AVS / \left[\ 1 + \left(\ UPPOTEN[AGE] \ / \ SATUPTAKE[AGE] \ \right) \ \right]$$

Uptake rates for other media are calculated in the same way.

The absorption coefficients for each medium (diet, water, dust, paint, soil, and alternate dust) are listed in Appendix A as Equations U-1a through U-1f. The saturable uptake component for each medium is simplified in the model source code as PAF for diet, water, dust and alternate dust, soil, and paint. Each saturable uptake component is set to a constant value except for PAF. The absorption coefficient for air is listed in Appendix A as Equation U-4. With the absorption coefficient for each medium, the total monthly lead uptake can be calculated using Equation U-5.

$$UPTAKE[MONTH] = 30 * \Big(UPDIET[MONTH] + UPWATER[MONTH] + UPDUST[MONTH] + UPSOIL[MONTH] + UPDUSTA[MONTH] + UPOTHER[MONTH] + UPAIR[MONTH] \Big) \qquad (U\text{-}5)$$

where:
30 = conversion factor from daily media-specific uptakes to monthly total uptake

2.3.3 Biokinetic Component

Based on the total lead uptake rate (UPTAKE[MONTH]), the biokinetic component of the IEUBKwin model calculates age-dependent lead masses in each of the body compartments (plasma-extra-cellular fluid (ECF), liver, kidney, trabecular bone, cortical bone, and other soft tissue). The concentration of lead in blood is then calculated by dividing mass of lead in the blood plasma and red blood cells by the volume of blood.

The calculations in the biokinetic module occur sequentially, beginning with a determination of the volumes and weights of specific compartments in a child's body, as a function of age. Next, the transfer times of lead between the compartments and through elimination pathways are estimated. Initial compartmental lead masses and an initial blood lead concentration are calculated for a newborn child. Then successive values are calculated for the compartmental lead masses and blood lead concentration of a child at each iteration time. These calculations are performed for a child from birth to age 84 months.

The equations for compartmental lead transfer times are listed in Appendix A as Equations B-1a through B-1h, B-2a through B-2o, and B-2.5. Equation B-2.5, as written in IEUBKwin model source code, indicates an age-dependent array for MRBC[MONTH]. The source code was taken directly from the IEUBK model (version 0.99d); thus, IEUBKwin model results are the same as those computed from the equation as written in the IEUBK model (version 0.99d) source code.

The parameter WTBODY(24) in Equations B-1a through B-1e has a default value of 12.3 in the model source code. For simplification purposes, storage arrays (ResCoef and ALLOMET) are used in the IEUBK model source code to store parameter and constant values in Equations B-1a through B-1g, B-2a, and B-3. The exponent, 0.333, in Equations B-1a through B-1e is stored in the ALLOMET array. Parameters such as TBLUR(24), TBLLIV(24), TBLOTH(24), TBLKID(24), TBLBONE(24), RATFECUR, and RATOUTFEC in Equations B-1a through B-1g and constants in Equations B-2a and B-3 are stored in the ResCoef array in the IEUBK model source code. The equations for blood to plasma_ECF lead mass ratio, fluid volumes and organ weights, difference equations, tissue lead masses and blood lead concentration at birth, compartmental lead masses, and blood lead concentration are B-3, B-4a through B-4d, B-5a through B-5m, B-6.5a through B-6.5i, B-7a through B-7i, B-8a through B-9i, and B-10a through B-10c, respectively (see Appendix A).

In the IEUBKwin model source code, the parameters in Equations B-8a through B-10a are set up as vectors that store 84 monthly values. The source code computes two values for each parameter, one for the current time step and one for the previous time step. These parameters are updated at the end of each time step. The difference in the implementation of these parameters in the IEUBKwin model source code does not affect the results of the model.

2.3.4 Probability Distribution Component

The fourth component of the IEUBKwin model estimates, for a hypothetical child or population of children, a plausible distribution of blood lead concentrations centered on the geometric mean blood lead concentration predicted by the model from available information about children's exposure to lead. From this distribution, the IEUBKwin model calculates the probability that children's blood lead concentrations will exceed the user-selected level of concern.

Risk estimation and plotting of probability distributions requires the selection of two parameters, the blood lead level of concern (cutoff level) and the Geometric Standard Deviation (GSD). A value of 10 µg/dL is generally used as the blood lead level of concern and 1.6 for the GSD, but other values can be selected by the user.

The user should note that results obtained from this version of IEUBKwin may differ slightly from results obtained from the 0.99d version and earlier versions of IEUBKwin (versions 244 and earlier). A primary reason for converting the IEUBK model from DOS to Windows was to take advantage of better mathematical features that are available with Windows. The IEUBKwin model results are more accurate than those obtained with the DOS version of the model. IEUBKwin v244 used distinct numerical integration algorithms to calculate Pc in the batch and single run mode. The single run mode used an approach known as the midpoint rule with a fixed integration interval (set as a multiple of the standard deviation of the Z-score), and batch mode used Simpson's Rule. For risk assessment purposes, in which low error is needed at the decision point of P10 = 5%, both approaches are sufficiently accurate. However, they yield slightly different results. The earlier versions of the model, when run in single run mode, produced step changes in P10 values as the geometric mean changed and yielded P10 values that were slightly lower than the values calculated in batch mode. In this version of IEUBK Win, the Pc algorithms have been revised so that the same algorithm is used in the batch and single modes. The current verison of the model uses the polynomial function, shown below, to calculate Pc. This approach is more accurate (error $< 10^{-8}$), more stable (i.e., it is not affected by the integration interval), and is more computationally efficient (i.e., iterative calculations are not needed to achieve a low error rate).

$$P(x) = 1 - Z(x)(b_1 t + b_2 t^2 + b_3 t^3 + b_4 t^4 + b_5 t^5) + \in(x)$$

$$x = \frac{\ln PbBcuttoff - \ln GM}{\ln GSD}$$

$$t = \frac{1}{1 + (p \cdot |x|)}$$

$$Z = \frac{1}{\sqrt{2\Pi}} \cdot e^{-(x^2/2)}$$

$$If\ \ x < 0\ then\ P(cutoff) = 1 - P(x)$$

$$If\ \ x > 0\ then\ P(cutoff) = P(x)$$

where:

(x) < 7.510^{-8} (error)
p = 0.2316419
b_1= 0.319381530
b_2 = -0.356563782
b_3 = 1.781477937
b_4 = -1.82125578
b_5 = 1.330274429

3.0 Software Detail Design

The detailed design of the IEUBKwin model is presented in this section. For each component and its associated modules, the inputs, processing in terms of calculations, and outputs are presented in table form.

3.1 OVERALL DESIGN DESCRIPTION

To design the IEUBKwin model, a series of menus was created from which the user can select screens for input of specific values appropriate to the situation that is being modeled. In general, the inputs, processing, and outputs are similar for all the model components—Exposure, Uptake, Biokinetic, and Probability Distribution. The inputs are values entered by the user or passed from the previous component. The processing performed is the solving of the algorithm for the particular component using the calculations identified in the requirements section (as determined by scientific research). The output is the values passed to the following component, used as input to the graphing routine, or the graph itself.

3.1.1 Local Data

The model uses local data only when the user calls up saved data as input to a graph. In addition, some of the components contain values that are coded internally, and which are accessed during the processing of algorithms.

3.1.2 Control

As a standalone system, internal control of the program is not a major issue. The system is dependent on the user entering adequate, valid, and complete data; once the model runs are initiated, the model runs as designed and tested.

3.1.3 Error Handling

The errors encountered by the IEUBKwin model are those relating to data input. When the user enters data that is invalid in terms of range or format, the system displays error messages which prompt the user to enter valid data. These are included in the IEUBKwin model's source code for every data input window for each model component.

In addition, the IEUBKwin model displays a warning message in the model output when the predicted blood lead concentration exceeds 30 µg/dL, the calibrated and empirical validation limit for predicted blood lead (Zaragoza, L. and Hogan, K., 1998. The Integrated Exposure Uptake Biokinetic Model for Lead in Children: Independent Validation and Verification. Environmental Health Perspectives 106 (supplement 6): 1555). However, empirical validation of the model did not address situations where the predicted blood lead concentration exceeds 30 µg/dL; therefore, such results must be interpreted with caution.

3.1.4 Data Conversion

In the IEUBKwin model, all parameters are allowed to be entered to six digits. All output values of the float type are controlled at 3 significant digits after the decimal except for blood lead concentration which is controlled to one significant figure after decimal point.

3.1.5 Test Structure

The testing structure for the IEUBKwin model is described in section 4.0.

3.1.6 Manual Procedures

The IEUBKwin model has a significant number of manual procedures simply because it is designed as a Windows system. The manual procedures include using the computer's mouse to select menus and to make selections from those menus. Once the selection has been made, the user must use the mouse and keyboard to input the required data. For saving results to a file, or identifying a previous results file as input to a graph, the user is prompted to enter the appropriate filenames.

To ensure compatibility with the Windows platform, several file names and data input windows required modification. All of the modifications suggested by the IV&V review were also incorporated in the Windows version. The modifications have no effect on the functionality of the IEUBKwin model. Table 2 contains the file extensions for the IEUBK (version 0.99d) and IEUBKwin models. No file extension equivalent exists in the IEUBKwin model for the DOS batch mode output file with the *.asc file extension since PBSTAT was not part of the conversion effort.

Output data from the batch mode runs are ASCII files that can be loaded into almost any statistical analysis package or spreadsheet program that the user may want to use. The IEUBKwin batch mode output files will require little or no editing before being imported into other programs, unless the missing value code (---) is incompatible with the user's package. It is recommended that the user apply a variety of graphical and statistical techniques in evaluating the output of batch mode model runs.

Table 2. File Extensions for DOS and Windows Versions of the IEUBK Model

Description	DOS File Name (0.99d)	Windows File Name
Single Run Model Text Results File	*.txt	*.txt
Single Run Model Plot File Distribution Probability Percent Plot File Probability Density Histogram Plot File	 none none	 *.grf *.grf
Multiple Runs Text Results File	*.txt	*.txt
Multiple Runs Plot File Distribution Probability for Multiple Runs Plot File Probability Density for Multiple Runs Plot File	 *.lay *.lay	 *.lay *.lay
Blood Pb Conc *vs*. Media Pb Conc Text Results File	*.txt	*.txt
Blood Pb Conc *vs*. Media Pb Conc Plot File	*.pbm	*.lin
Load Parameters from File	*.sv3	*.svd
Save Parameters to File	*.sv3	*.svd
Batch Mode Input File	*.dat	*.dat
Batch Mode Output Files	*.txt *.asc (used in PBSTAT)	*.txt none
Media-specific Parameter Inputs Storage Files	none	*.tmp

3.2 EXPOSURE COMPONENT

The various media exposure modules are presented in the following subsections. For each exposure module, the inputs are listed along with descriptions of the sequential functions that occur in processing.

3.2.1 Air Lead Exposure Module

Inputs (from the Air Data Window): air_absorp[0], air_absorp[1], air_absorp[2], air_absorp[3], air_absorp[4], air_absorp[5], air_absorp[6], time_out[0], time_out[1], time_out[2], time_out[3], time_out[4], time_out[5], time_out[6], vent_rate[0], vent_rate[1], vent_rate[2], vent_rate[3], vent_rate[4], vent_rate[5], vent_rate[6], air_concentration[0], air_concentration[1], air_concentration[2], air_concentration[3], air_concentration[4], air_concentration[5], air_concentration[6], indoorpercent

ClassName.Function	**Description**
CAir.Check_Data_Valid()	Checks whether input data is within the acceptable range. If not, the user is prompted that invalid data was entered and to try again.
CAir.UpdateData()	Updates and stores data temporarily in a file called "Air.tmp." UpdateData() takes the user input data to the application.
CAir.Air_TakeData()	Opens and reads data from "Air.tmp" or "Air.inp." The file "Air.inp" stores default values for each of the variables listed under Inputs. Numeric values for air_absorp[0], air_absorp[1], air_absorp[2], air_absorp[3], air_absorp[4], air_absorp[5], air_absorp[6], time_out[0], time_out[1], time_out[2], time_out[3], time_out[4], time_out[5], time_out[6], vent_rate[0], vent_rate[1], vent_rate[2], vent_rate[3], vent_rate[4], vent_rate[5], vent_rate[6], air_concentration[0], air_concentration[1], air_concentration[2], air_concentration[3], air_concentration[4], air_concentration[5], and air_concentration[6] are stored in the following arrays: air_absorp[AGE], time_out[AGE], vent_rate[AGE], and air_concentration[AGE].
CAir.Calc_INAIR()	Calculates INAIR[AGE] using Equations E-1 through E-3.
CAir.Write_Data_File()	Writes input data to a temporary file.

3.2.2 Dietary Lead Exposure Module

Inputs (from the Dietary Data Window): diet_intake[0], diet_intake[1], diet_intake[2], diet_intake[3], diet_intake[4], diet_intake[5], diet_intake[6], YesNo_AlternativeDiet, UserFishConc, userFishFracPercent, UserFruitConc, userFruitFracPercent, UserGameConc, userGameFracPercent, UserVegConc, userVegFracPercent, userFishFraction, userVegFraction, userFruitFraction, userGameFraction

Class Name.Function	Description
CDiet.Check_Data_Valid()	Checks whether input data is within the acceptable range. If not, the user is prompted that invalid data was entered and to try again.
CDiet.UpdateData()	Updates and stores data temporarily in a file called “Diet.tmp.” UpdateData() takes the user input data to the application. Percent values for userFruitFracPercent, userGameFracPercent, userFishFracPercent, and userVegFracPercent are converted to their decimal fraction equivalent.
CDiet.Diet_TakeData()	Opens and reads data from “Diet.tmp” or “Diet.inp.” The file “Diet.inp” stores default values for each of the variables listed under Inputs. Numeric values for m_diet_intake[0], diet_intake[1], diet_intake[2], diet_intake[3], diet_intake[4], diet_intake[5], and diet_intake[6] are stored in the array diet_intake[AGE].
CDiet.Calc_INDIET()	Calculates INDIET[AGE] whose value depends on the value of YesNo_AlternativeDiet. If YesNo_AlternativeDiet=0, INDIET[AGE] is calculated using Equation E-4a; otherwise, INDIET[AGE] is calculated using Equations E-4b and E-5a through E-5i.
CDiet.Write_Data_File()	Writes input data to a temporary file.

3.2.3 Water Lead Exposure Module

Inputs (from the Water Data Window): constant_water_conc, water_consumption[0], water_consumption[1], water_consumption[2], water_consumption[3], water_consumption[4], water_consumption[5], water_consumption[6], FirstDrawConc, HomeFlushedConc, FountainConc, FirstDrawPercent, FountainPercent, FountainFraction, FirstDrawFraction, YesNo_AlternativeWater.

Class Name.Function	**Description**
CWater.Check_Data_Valid()	Checks whether input data is within the acceptable range. If not, the user is prompted that invalid data was entered and to try again.
CWater.UpdateData()	Updates and stores data temporarily in a file called "Water.tmp." UpdateData() takes the user input data to the application. Percent values for FirstDrawPercent and FountainPercent are converted to their decimal fraction equivalent.
CWater.Water_TakeData()	Opens and reads data from "Water.tmp" or "Water.inp." The file "Water.inp" stores default values for each of the variables listed under Inputs. Numeric values for water_consumption[0], water_consumption[1], water_consumption[2], water_consumption[3], water_consumption[4], water_consumption[5], and water_consumption[6] are stored in the array water_consumption[AGE].
CWater.Calc_INWATER()	Calculates INWATER[AGE] whose value depends on the value of YesNo_AlternativeWater. If YesNo_AlternativeWate r= 0, INWATER[AGE] is calculated using Equation E-6a; otherwise, INWATER[AGE] is calculated using Equations E-6b and E-7.
CWater.Write_Data_File()	Writes input data to a temporary file.

3.2.4 Soil/Dust Lead Exposure Module

Inputs (from the Soil/Dust Window): weight_soil, soil_indoor[0], soil_indoor[1], soil_indoor[2], soil_indoor[3], soil_indoor[4], soil_indoor[5], soil_indoor[6], soil_content[0], soil_content[1], soil_content[2], soil_content[3], soil_content[4], soil_content[5], soil_content[6], soil_ingested[0], soil_ingested[1], soil_ingested[2], soil_ingested[3], soil_ingested[4], soil_ingested[5], soil_ingested[6], contrib_percent, multiply_factor, OtherConc, OtherFraction, SchoolConc, SchoolFraction, SecHomeConc, SecHomeFraction, DaycareConc, DaycareFraction, OccupConc, OccupFraction, AvgMultiSrc, HouseFraction, constant_soil_conc[0], constant_soil_conc[1], constant_soil_conc[2], constant_soil_conc[3], constant_soil_conc[4], constant_soil_conc[5], constant_soil_conc[5], constant_dust_conc[0], constant_dust_conc[1], constant_dust_conc[2], constant_dust_conc[3], constant_dust_conc[4], constant_dust_conc[5], constant_dust_conc[6], out_air_concentration[0], out_air_concentration[1], out_air_concentration[2], out_air_concentration[3], out_air_concentration[4], out_air_concentration[5], out_air_concentration[6], const_outdoor_soil, const_indoor_dust, dust_indoor[0], dust_indoor[1], dust_indoor[2], dust_indoor[3], dust_indoor[4], dust_indoor[5], dust_indoor[6], vary_indoor, vary_outdoor

Class Name.Fucntion	**Description**
CSoil.Check_Data_Valid()	Checks whether input data is within the acceptable range. If not, the user is prompted that invalid data was entered and to try again.
CSoil.UpdateData()	Updates and stores data temporarily in a file called "Soil.tmp." UpdateData() takes the user input data to the application. Percent values for DaycareFracPercent, OccupFracPercent, OtherFracPercent, SchoolFracPercent, SecHomeFracPercent, and HouseFracPercent are converted to their decimal fraction equivalent.
CSoil.Soil_TakeData()	Opens and reads data from "Soil.tmp" or "Soil.inp." The file "Soil.inp" stores default values for each of the variables listed under Inputs. Numeric values for soil_indoor[0], soil_indoor[1], soil_indoor[2], soil_indoor[3], soil_indoor[4], soil_indoor[5], soil_indoor[6], soil_content[0], soil_content[1], soil_content[2], soil_content[3], soil_content[4], soil_content[5], soil_content[6], soil_ingested[0], soil_ingested[1], soil_ingested[2], soil_ingested[2], soil_ingested[3], soil_ingested[4], soil_ingested[5], and soil_ingested[6] are stored in the following arrays: soil_indoor[AGE], soil_content[AGE], and soil_ingested[AGE].
CSoil.Calc_INSOIL()	Calculates INSOIL[AGE], INDUST[AGE], and INDUSTA[AGE] whose values depend on the values of m_altsrc, vary_indoor, vary_outdoor.
CSoil.Write_Data_File()	Writes input data to a temporary file.
CSoil.GetExtraData()	Takes data from the air module and MSA.
CSoil.MSA_TakeData()	Takes data from the MSA.

3.2.5 Maternal Lead Exposure Module

Inputs (from the Maternal Data Window): PBBLDMAT

Class Name.Function	**Description**
CMaternal.Check_Data_Valid()	Checks whether input-data is within the acceptable range. If not, the user is prompted that invalid data was entered and to try again.
CMaternal.UpdateData()	Updates and stores data temporarily in a file called "Maternal.tmp." UpdateData() takes the user input data to the application.
CMaternal.Maternal_TakeData()	Opens and reads data from "Maternal.tmp" or "Maternal.inp." The file "Maternal.inp" stores default values for each of the variables listed under Inputs.
CMaternal.Write_Data_File()	Writes input data to a temporary file.

3.2.6 Other Lead Exposure Module

Inputs (from the Alternate Source Data Window): other_intake[0], other_intake[1], other_intake[2], other_intake[3], other_intake[4], other_intake[5], other_intake[6].

Class Name.Function	**Description**
COther.Check_Data_Valid()	Checks whether input data is within the acceptable range. If not, the user is prompted that invalid data was entered and to try again.
COther.UpdateData()	Updates and stores data temporarily in a file called "Other.tmp." UpdateData() takes the user input data to the application.
COther.Other_TakeData()	Opens and reads data from "Other.tmp" or "Other.inp." The file "Other.inp" stores default values for each of the variables listed under Inputs. Numeric values for other_intake[0], other_intake[1], other_intake[2], other_intake[3], other_intake[4], other_intake[5], and other_intake[6] are stored in the array other_intake[AGE].
COther.Write_Data_File()	Writes input data to a temporary file.

3.2.7 GI/Bioavailability Module

Inputs (from the Alternate Source Data Window): ABSPPercent, ABSSPercent, ABSD percent, ABSF Percent, ABSW Percent, PAFs, SATINTAKE2.

Class Name.Function	**Description**
CGiBio.Check_Data_Valid()	Checks whether input data is within the acceptable range. If not, the user is prompted that invalid data was entered and to try again.
CGiBio.UpdateData()	Updates and stores data temporarily in a file called “GiBio.tmp.” UpdateData() takes the user input data to the application.
CGiBio.Other_TakeData()	Opens and reads data from “GiBio.tmp” or “GiBio.inp.” The file “GiBio.inp” stores default values for each of the variables listed under Inputs.
CGiBio.Write_Data_File()	Writes input data to a temporary file.

3.3 UPTAKE COMPONENT

The inputs to the Uptake component are listed below along with a description of the function that occurs in the model processing.

Inputs: These variables were derived from the Exposure Component of the model: INAIR[AGE], INSOIL[AGE], INDUST[AGE], INDUSTA[AGE], INWATER[AGE], INDIET[AGE], INOTHER[AGE], PBBLDMAT

ClassName.Function	**Description**
BaseComp.Calc_UPTAKE()	Calculates the values for UPAIR[MONTH], UPDIET[MONTH], UPDUST[MONTH], UPDUSTA[MONTH], UPSOIL[MONTH], UPWATER[MONTH], UPOTHER[MONTH], and UPTAKE[MONTH] using Equations U-1a through U-1f, U-2, U-3, U-4, and U-5.

3.4 BIOKINETIC COMPONENT

The inputs to the Biokinetic component are listed below along with a description of the function that occurs in the model processing.

Inputs: This variable was derived from the Uptake Component of the model: UPTAKE[MONTH]

Class Name.Function	Description
BaseComp.Calc_Biokinetic()	Calculates the lead masses in each body compartments (MPLECF[2], MPLASM[2], MRBC[2], MLIVER[2], MKIDNEY[2], MOTHER[2], MTRAB[2], and MCORT[2]) using the difference equations B-6.5a through B-6.5i and intermediate equations B-1a through B-1h, B-2a through B-2o, B-2.5, B-3, B-4a through B-4d, B-5a through B-5m, B-6.5a through B-6.5i, B-7a through B-7i, B-8a through B-8d, B-9a through B-9i, and B-10a through B-10c.

4.0 Documentation for the IEUBKwin

Several documents are required as documentation for the IEUBKwin model. The *System Requirements and Design* is designed for use by programmers. By contrast, The *User's Guide and Reference Manual* will be widely used by end users of the IEUBKwin model.

The system documentation for the IEUBKwin model was first proposed in October 27, 1997. Since that communication, the system documentation has evolved to include the following:

- System Requirements and Design Specifications
- Complete printout of the IEUBK model source code
- Data Crosswalk from DOS 0.99d version to IEUBKwin
- Data Elements Dictionary

These documents were prepared according to the *OSWER System Life Cycle Management Guidance* (April 1988). The audience for these documents will be programmers. The purpose of these documents was to demonstrate that the recoding of the IEUBK model was performed correctly and to document the recoding effort to satisfy challenges, questions, and concerns from Congress as well as PRP litigation. The system documentation will also be an important reference for the future in the event that enhancements to the IEUBKwin model are necessary. Changes to the IEUBKwin model may occur because of changes in the scientific understanding that affect equations or defaults in the current model source code. The detailed design documentation will assist future designers and programmers with system maintenance by clearly defining the current system requirements and technical design.

The second part of the guidance documentation is intended for end users and will consist of two separate documents: (1) a User's Guide, a succinct document explaining how to install and run the IEUBKwin model; and (2) a Reference Manual, a concise document explaining the changes to the IEUBK model since the IV&V and the enhancement made in the conversion to windows.

5.0 Testing and Verification Requirements

There are three purposes for testing the IEUBKwin model. First, the IEUBKwin model must be tested to determine whether it produces the same results as the DOS version for the same function with the same input data. Second, the IEUBKwin model must be tested to determine how it functions in terms of screen handling and whether its operation is clear, logical, and comprehensible. Third, the IEUBKwin must be tested to measure its performance compared to the DOS (version 0.99d) model.

5.1 SOFTWARE TEST

All of the IEUBKwin model functions were tested using three different datasets. Output from the IEUBKwin model was plotted in several ways, and printed to compare with the IEUBK DOS model. Testing was performed for each roll-out version of the IEUBKwin model. The first test began on November 4 and ended on November 12, 1997. Subsequent tests began in 1998 and continued until release of the latest version.

5.1.1 Software Test Requirements

A Software Testing and Quality Assurance Plan was developed for the IEUBKwin model to ensure that the model functioned properly and that it had been implemented as planned. It is also important to determine whether the model was easy to use, and if screen manipulation and input procedures made sense to the user. Therefore, the test requirements were to test the results of the IEUBKwin model against the results of the model for the following:

- ✓ Batch runs
- ✓ Individual model runs

5.1.2 Software Test Procedures

The software testing was executed by a team that did not include any of the software developers. This was intended to provide a test environment that was not biased by knowledge of the system development efforts. The purpose of this team composition was to represent a range of users and thus cover a wide variety of points of view of those reviewing the system. Before beginning the actual test, test team members were asked to review the following background material:

- *Guidance Manual for the Integrated Exposure Uptake Biokinetic Model for Lead in Children*

- *Technical Support Document (TSD)*: *Parameters and Equations Used in the Integrated Exposure Uptake Biokinetic (IEUBK) Model for Lead in Children* (v. 0.99d)

The following steps were followed by the test team:

1. Tested individual runs for each function. Tested once using the original DOS model. Tested again using the Windows model.

2. Tested all reporting modules. Plotted the results in as many ways as possible, including using the results for PBSTAT runs.

3. Used the test data located on the Local Area Network. Used the dataset called “patdata.txt” for individual runs of the model. Printed the data, then input the individual data elements into the appropriate places in the model using the column header as a guide. For batch run testing, used the data set called “testdata.dat” for the DOS model, and the dataset called “testdata.dat” and “midvale.dat” for the Windows model. These data sets were formatted for input as batch mode files. In addition other data sets were available to the test group (including data from Sandy Smelter Site and Palmerton Zinc NPL Site).

4. When each test run was complete, results were printed and labeled. Compared the results from the DOS and the Windows model runs.

5. Documented discrepancies between the results using the Discrepancy Reporting Sheet for the IEUBKwin Model Testing (Figure 5).

6. If there was an input or help screen that needed to be changed, the screen was printed. Changes and/or comments were marked on the printout.

7. Additional comments or concerns about the IEUBKwin model were noted on a separate sheet (such as the appearance of input and help screens, vague or incorrect screen directions, or incorrect destinations of buttons or menu selections).

5.1.3 Conducting the Software Test

The initial testing team for the IEUBKwin model consisted of technical staff from ISSI and Syracuse Research Corporation. More than 20 people participated in the testing which included persons not involved in the recoding effort. The testers received the DOS (version 0.99d) and the IEUBKwin models, and several data sets. The IEUBK Guidance Manual and the TSD (December 1994) were used as references for the type of data used in testing the IEUBKwin model. The data for testing included both hypothetical and actual data. Two hypothetical data sets TESTDATA.TXT and XYZDATA.TXT were prepared as batch mode input files. There were three sets of actual data from Superfund lead sites (Midvale, Palmerton, and Sandy). Testers were free to experiment with other data for individual and batch mode runs. All testing was performed twice: once using DOS (version 0.99d) and once in the IEUBKwin model. Results from the both versions were printed and compared. Any discrepancies found were reported using the form shown in Figure 5.

An informal requirements analysis was conducted with the EPA's Technical Review Workgroup for Lead (TRW) prior to the distribution of the third-party testing version of the IEUBKwin model.

5.1.4 Software Test Results

All reporting modules were tested. Results were plotted in a variety of ways, including using the results for PBSTAT runs (refer to guidance manual). For the Phase I testing, 31 defects and 14 enhancements were reported. During the Phase II testing, there were 12 defects and 10 enhancements reported. All defects were resolved and approved enhancements were incorporated before the roll-out of the third-party testing version.

Discrepancy Reporting Sheet for IEUBKwin Testing

Tester's name:

Date:

Data set used:

Conditions of run:

Results for both DOS and Windows:

Other problems encountered:

Notes:

Figure 5. Discrepancy Reporting Sheet for IEUBKwin Model Testing.

5.2 PERFORMANCE TEST

The performance test evaluated the responsiveness of the model in processing a user request and the integrity of the system in processing, managing, and storing data on 12 different performance test pathways.

5.2.1 Performance Test Procedure

Four PC environments were used to test the performance of the IEUBKwin model. The IEUBKwin model was tested locally from the hard drive. Table 3 describes each of the performance test pathways that were used on each of the four PC environments for the testing. The IEUBK DOS (version 0.99d) model was tested on the same performance pathways as described below on a 486DX platform. All temporal results will be reported in seconds.

Table 3. Template for Performance Pathways and PC Environment

Pathway Description	Environment 1: 486DX/12MB	Environment 2: P120/32MB	Environment 3: P166/16MB	
Running the IEUBK Model				
Double-click on IEUBKwin from File Manager (Windows Explorer) to run model.				
Viewing Text Results				
Computation>Run the Model Press the OK button from the Show Results As... Window to run Single Run using default values.				
Computation>Multiple Runs Press the OK button from the Show Results As... Window to run Multiple Runs using default parameter values.				
Computation > PbB vs Media Conc. Press the OK button from the Show Results As... Window to run Blood lead vs Media Conc using default parameter values.				

Pathway Description	Environment 1: 486DX/12MB	Environment 2: P120/32MB	Environment 3: P166/16MB	
Computation>Find Media Conc. (PbB) Press the Run button from the Media Concentration (Known PbB Level) Window using the following data: Soil, 0 to 6 mos, and 30 as the Known PbB Conc.				
Computation>Batch Mode Model Run Press the Start button from Batch Mode Model Run Window to run a 2KB batch file.				
Computation>Batch Mode Model Run Press the Start button from Batch Mode Model Run Window to run a 10KB batch file.				
Viewing Graphical Results				
Graph>PbB Conc vs Media Pb Conc Press the OK button from the Open Window to display graph.				
Graph>Distribution Probability Percent Press Show Graph button from Probability for Multiple Runs Window to display graph.				
Graph>Probability Density Histogram Press Show Graph button from Probability for Multiple Runs Window to display graph.				

5.2.2 Performance Test Results

Table 4 describes the results of the performance test on the Windows version for each PC environment. The IEUBK DOS model was only tested on a 486DX environment. The results from the IEUBK DOS model test are indicated in italics. The results in Table 2 show that the Windows version runs much faster than the DOS version. In exporting a 10KB batch file, the Windows version is at least 3 times faster than its counterpart.

Table 4. Results from Performance Testing

Pathway Description	Environment 1: 486DX/12MB	Environment 2: P120/32MB	Environment 3: P166/16MB	
Running the IEUBK Model				
Double-click on IEUBKwin from File Manager (Windows Explorer) to run model.	Approx. 1sec *DOS: Approx. 5 sec*	Approx. 1 sec	Approx. 1 sec	Approx. 1 sec
Viewing Text Results				
Computation>Run the Model Press the OK button from the Show Results As... Window to run Single Run using default values.	Approx. 1 sec *DOS: Approx. 2 sec*	Approx. 1 sec	Approx. 1 sec	Approx. 1 sec
Computation>Multiple Runs Press the OK button from the Show Results As... Window to run Multiple Runs using default parameter values.	Approx. 1 sec *DOS: Approx. 2 sec*	Approx. 1 sec	Approx. 1 sec	Approx. 1 sec
Computation > PbB vs Media Conc. Press the OK button from the Show Results As... Window to run PbB vs Media Conc using default parameter values.	Approx. 1 sec *DOS: Approx. 14 sec*	Approx. 1 sec	Approx. 1 sec	Approx. 1 sec
Computation>Find Media Conc. (PbB) Press the Run button from the Media Concentration (Known PbB Level) Window using the following data: Soil, 0 to 6 mos, and 30 as the Known PbB Conc.	Approx. 9 sec *DOS: Approx. 10 sec*	Approx. 4 sec	Approx. 4 sec	Approx. 2 sec

Pathway Description	Environment 1: 486DX/12MB	Environment 2: P120/32MB	Environment 3: P166/16MB	
Computation>Batch Mode Model Run Press the Start button from Batch Mode Model Run Window to run a 2KB batch file.	Approx. 20 sec *DOS: No file available*	Approx. 9 sec	Approx. 7 sec	Approx. 5 sec
Computation>Batch Mode Model Run Press the Start button from Batch Mode Model Run Window to run a 10KB batch file.	Approx. 89 sec *DOS: Approx. 274 sec*	Approx. 58 sec	Approx. 35 sec	Approx. 31 sec
Viewing Graphical Results				
Graph> PbB Conc vs Media Pb Conc Press the OK button from the Open Window to display graph.	Approx. 1 sec *DOS: Approx. 1 sec*	Approx. 1 sec	Approx. 1 sec	Approx. 1 sec
Graph>Distribution Probability Percent Press Show Graph button from Probability for Multiple Runs Window to display graph.	Approx. 1 sec *DOS: Approx. 1 sec*	Approx. 1 sec	Approx. 1 sec	Approx. 1 sec
Graph>Probability Density Histogram Press Show Graph button from Probability for Multiple Runs Window to display graph.	Approx. 1 sec *DOS: Approx. 1 sec*	Approx. 1 sec	Approx. 1 sec	Approx. 1 sec
Graph>Distribution Prob. for Multiple Runs Press Show Graph button from Probability for Multiple Runs Window to display graph.	Approx. 1 sec *DOS: Approx. 3 sec*	Approx. 1 sec	Approx. 1 sec	Approx. 1 sec
Graph>Prob. Density for Multiple Runs Press Show Graph button from Probability for Multiple Runs Window to display graph.	Approx. 1 sec *DOS: Approx. 1 sec*	Approx. 1 sec	Approx. 1 sec	Approx. 1 sec